1.0 INTRODUCTION

The southwest coast of Florida is characterized by a number of important estuarine systems, including Tampa Bay, Sarasota Bay, Charlotte Harbor, and Estero Bay. The degree of local, state, and federal concern regarding existing and potential impacts to these systems resulting from hydrologic alterations and the degradation of water quality is indicated by the fact that these estuaries have been designated for special study, protection and restoration as part of three separate regional National Estuary Programs. These programs have identified similar stresses to each of these estuaries associated with the rapid development which has been occurring over the past four decades throughout southwest Florida. In general, the need for restoration activities has been shown to be greatest for the more northern estuarine systems, where the impacts associated with surrounding development have been both more intense and extended back to prior to the implementation of many of the current environmental regulations and management practices. Conversely, the National Estuary Programs have indicated the potential opportunities for prevention and preservation to be the greatest within the watersheds surrounding the more southern southwest Florida estuaries where historic development has been less intense.

The purpose of Volume E is to outline a monitoring program which will allow evaluation of existing and future alterations of both water quantity and quality within the Estero Bay Watershed (Figure 1-1). The monitoring program is intended to produce an understanding of the existing hydrologic and pollutant loadings from the watershed and its individual land forms and an evaluation of existing and proposed management practices to support the formulation of effective changes and which will, where appropriate, advance the attainment of specific identified goals. Such goals may include reductions of:

- excessive nutrient loadings,
- unrestrained or poorly-timed unnatural freshwater inputs, and
- extreme sediment loadings.

This volume, Volume E, is one of a series of volumes which make up the Estero Bay and Watershed Assessment Plan. The complete series of volumes is:

- Volume A. Literature Survey of the Estero Bay Watershed
- Volume B. Characterization Report
- Volume C. Basin Prioritization Report
- Volume D. Management Goals Report
- Volume E. Monitoring Report
- Volume F. Estero Bay Research Plan

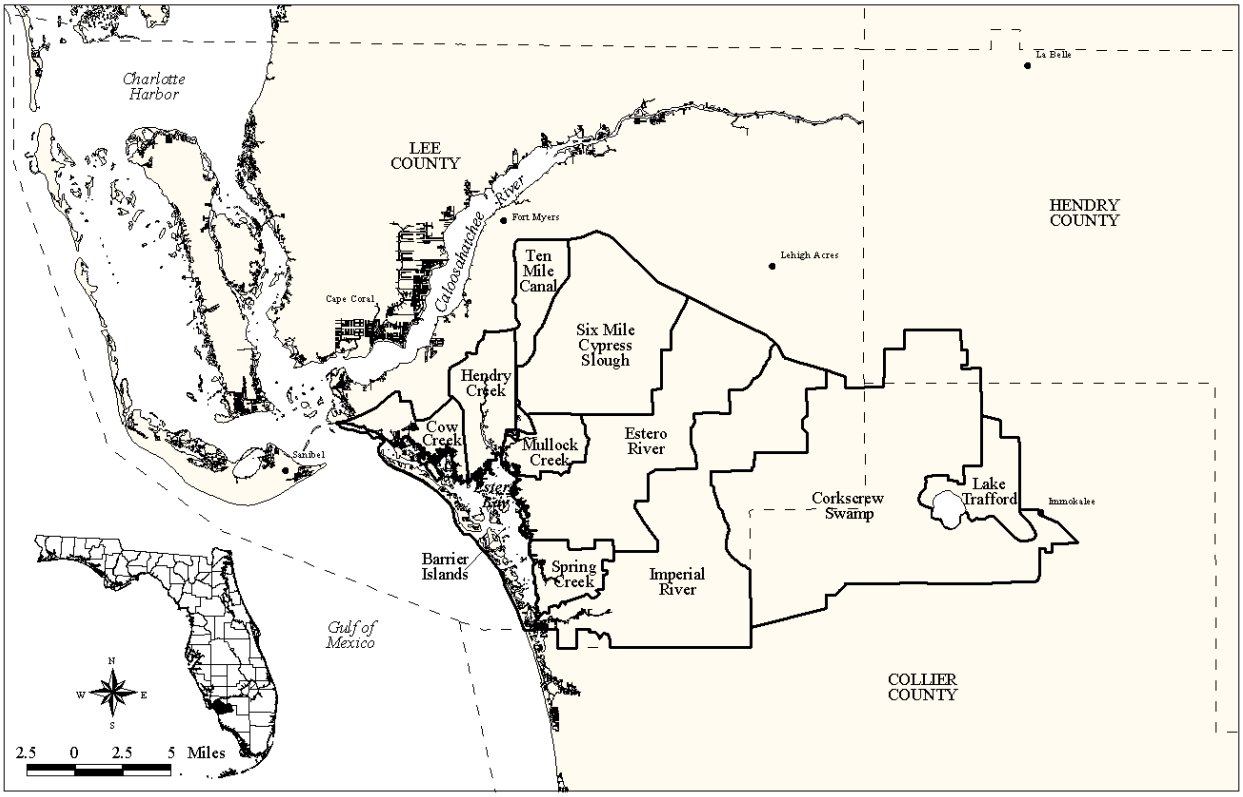

Figure 1-1. Location of the Estero Bay Watershed.

1.1. Water Quality Modeling

To support the initial objectives of reducing nutrient and sediment loadings and implement effective management practices to modify the quantity and timing of freshwater inputs to the estuary, the South Florida Water Management District (SFWMD) intends to use the tools of computerized hydrologic and water quality modeling to aid in establishing both the relative levels of impacts and predicting the effectiveness of potential improvements. It is necessary to monitor both long-term conditions at various locations as well as intensively under specific conditions throughout the watershed to provide the necessary data for comparison with the model predictions so that model performance can be made representative of the actual situation in the watershed. Once a representative model is developed, it may then be used to predict the comparative conditions within the watershed system under both existing and hypothetical future conditions following implementation of proposed major basin retrofits and revised management practices.

The model chosen for the evaluation is the U.S. Environmental Protection Agency's Hydrologic Simulation Program - FORTRAN (HSPF). The HSPF model provides comprehensive water quality simulation capabilities at the cost of extensive, sometimes excessive, data and model parameter development requirements to fully use all of the detailed features of the model. Extensive monitoring data are needed to support model parameter development, calibration and verification of the modeled processes, to develop guidelines for implementation of revised management practices, and to assess the actual performance of the watershed system as changes occur over time.

The HSPF model framework allows the simulation of upland watershed areas to generate runoff loadings and the receiving water system through which flows are routed. The model is oriented to continuous simulation, using time series data inputs such as rainfall, evapotranspiration, external stream flows and pollutant concentrations and loadings to drive the simulation. The model produces a time history of flows and water quality constituent mass loads or concentrations at any point in the simulated system.

Characteristics of upland areas (subbasins) are generally developed from topography and detailed land use and soils data and can incorporate knowledge of local practices such as fertilizer application rates and management practices. Detailed geometric data and flow characteristics are needed for the flow conveyance system. The flow routing portion of the existing model treats each element as a well-mixed body and performs a fairly simple unidirectional kinematic routing calculation.

The simulation of the hydrologic behavior and transport of water and pollutants from the land surface is performed primarily in the PERLND (pervious land) module of the model. The RCHRES (reach/reservoir) module performs the calculations needed to simulate the hydraulic and water quality behavior of each receiving water segment (or reach) in the modeling network. Both the PERLND and RCHRES modules of the model have been upgraded as part of previous District projects. PERLND was modified to handle high water table conditions, while RCHRES was altered

to add capabilities for both fully dynamic routing and to explicitly account for control structures. The model accounts for structures such as weirs with and without bleeddown mechanisms, manual or automatic gated weirs, culverts and culverts with risers, flap gates, pumps as well as various combinations. In addition a new wetland module has also been under development.

1.2. Monitoring Program

The monitoring data requirements necessary for modeling with HSPF are generally flexible due to the model's nature and the potential application of simpler and more detailed simulation approaches. As such, an initial important consideration during the development of the monitoring program recommendations for the Estero Bay Watershed is the level of detail which will be attempted in the modeling. The questions asked and potential level of complexity of the model will both have an important bearing on data requirements. The modeling algorithms available within HSPF vary greatly in the both the amount and kinds of information required, both of which are dependent upon the specific conditions of the modeling effort which is to be used. Such distinctions in modeling efforts include complexities such as those associated with soil nutrient simulations and variable approaches to simulating varying in-stream processes.

The development of the specific monitoring program recommendations within this document has focused primarily on the necessity of obtaining those overall watershed data necessary to develop long-term inflow-outflow characterizations of conditions within the Estero Bay Watershed and to obtain both short-term specific evaluations of localized land use loadings as well as assess the relative performances of existing management practices. Although the use of simpler modeling methods and protocols is generally recommended wherever possible, the water quality data obtained in conjunction with these monitoring efforts should be collected in such a manner as to support any of the modeling approaches available within HSPF. This dual approach will require, for example, that common forms of the macro-nutrients nitrogen and phosphorus be determined in addition to only the simpler measurements of "total" available concentrations. In addition, normal *in situ* data physical water quality characteristics including temperature, dissolved oxygen, conductivity and pH should also be measured. This will both maximize the options available for water quality evaluations and provide opportunities for comparisons of conditions within the watershed employing differing modeling approaches within HSPF, while at the same time providing for continuity with existing and potential future long-term data collections. As a general guideline, the monitoring program should focus on identifying to the greatest extent possible, both the external and internal sources of loading within the Estero Bay Watershed.

The proposed monitoring program elements include continuation and enhancement of existing long-term data collections as well as augmentation by both synoptic and event oriented sampling strategies. In addition, attention should be given to synchronizing data collections under both existing and future monitoring program initiatives, if possible, to gain the greatest utility from all of the data sets collected. A key element of the monitoring program is the need for specific short-term

land use loading studies to develop local characterization data and assess the effectiveness of existing management practices. Such short-term loading studies are proposed to discriminate possible differences in loadings generated by agricultural uses as well as those employing different irrigation practices. In addition, short-term loading studies are proposed to directly assess the effectiveness of differing management practices associated with urban development and the establishment of stormwater control systems. Periodic synoptic sampling is specifically suggested as a primary methodology to provide the additional data needed to characterize specific pollutant concentration profiles in the major watershed conveyances and to seek out and identify relative major problem areas within the Estero Bay Watershed. The proposed studies focus on specific characteristic elements of the watershed necessary to identify and characterize the most problematic areas. These results will then be used to help and guide the future development of effective alternative management practices where necessary and establish criteria and goals for retrofit and mitigation activities with the watershed.

1.3. Approach to Modeling

The primary benefits of the water quality modeling efforts will be dependent upon the model's ability to perform accurate hydrologic and hydraulic assessments of the watershed's characteristics under differing conditions. It is probable that the major reductions of both nutrient and sediment loadings achievable within the Estero Bay Watershed will be directly proportional to the ability of the responsible parties to control, manipulate, reduce, and treat hydrologic discharges under specific rainfall conditions. As such, the use whenever possible of the simplified water quality modeling methods is recommended for the following reasons:

- simpler water quality modeling methods should be sufficient to adequately address the goals of reducing loadings of total macro-nutrients such as total nitrogen and total phosphorus, as well as total suspended solids;

- the success of the modeling efforts are generally dependent on the model's ability to correctly simulate variations in watershed hydrology and hydraulics, while water quality calculations are usually secondary in nature;

- detailed water quality model routines require significantly greater efforts to accurately employ, with little guarantee that the resulting modeling predictions will be proportionately improved;

- detailed water quality routines within the existing model associated with upland subsurface nutrient processes have limitations which could pose serious modeling difficulties to accurate assessments in the Estero Bay Watershed; and

- the hydrologic and hydraulic upgrades which have been made to the model will undoubtedly require significant testing before their direct application to the Estero Bay Watershed system can accurately be evaluated.

Therefore, the HSPF model's ability to predict and transport pollutant loadings using simplified modeling approaches will be of more importance to its application to the Estero Bay Watershed assessment work efforts than its particular abilities to simulate detailed subsurface soil processes or accurately estimate detailed in-stream processes. The unknowns resulting from the model's hydrologic and hydraulic upgrades further support the initial use of simplified modeling methods. In the future, additional studies of detailed processes in the field combined with more advanced modeling may emerge as a higher priority once the major assessments have been achieved in improving past detrimental hydrologic alterations which have occurred in the watershed.

The HSPF model provides comprehensive simulation capabilities. Nevertheless, there are a number of deficiencies and limitations in the available algorithms. Based on the principles of structured programming, the HSPF model was developed in a manner which readily supports revisions and additions to the simulation algorithms. However, incorporation of modeling code changes is not a trivial process due to the size and complexity of the model. Model documentation is complete but may be unintentionally misleading in places due to fairly terse presentation of the modeling algorithms, limited explanation of their development history and underlying assumptions, and limited information about how the calculations are actually performed. Model limitations and some recommended upgrades, mainly for the detailed upland nutrient simulation routines may be appropriate. However, based on the District's previous experience in using the HSPF model, the development of fundamental watershed-specific changes in the model's hydrologic and hydraulic performance capabilities may confound the estimations derived from the water quality routines. The performance of many of the routines will be similar to the basic model, while others may be improved to partially or completely overcome existing problems. However, such changes may also result in new and unexpected problems. Extensive watershed-specific testing of the model will be necessary to establish a full understanding of model performance resulting from any changes or enhancements.

The following chapters of this report provide a description of recommended monitoring activities and the support provided directly and indirectly for the modeling effort in the form of required and optional model input parameters and time series data needed for different modeling approaches. The materials presented in this document are drawn from the experiences of many workers in the field. The detailed listing of model parameters borrows heavily from the model documentation to form an annotated summary compilation intended for reference and to provide a useful starting point for modeling. The monitoring program is intended to form a foundation to support the modeling effort in an attempt to anticipate the most critical data needs to address the immediate problems of the watershed.

It should be noted that a great deal of judgement and experience is required to accurately develop an appropriate watershed modeling effort, including a critical review of all available data. This includes those data collected during the model's development in order to assess what parameters or additional data may be needed or desirable. As only one example, the validity and applicability of data obtained from the recommended land use loading studies may not be known until the obtained data are applied to the watershed-wide modeling effort. Despite every best effort to select, instrument, and monitor representative sites, the data simply may not work to produce the desired modeling results for any number of reasons, including variability in weather conditions and variability in local land management activities preceding actual sampling events. The monitoring program should be carried out in a flexible manner so that additional data needs can be accommodated as the modeling effort undergoes various levels of refinement.